1.0 Introduction

This document provides technical background information on the Industrial Waste Management Evaluation Model (IWEM). A companion document, the *IWEM User's Guide* provides detailed information on how to install and use the IWEM software that is distributed as part of U.S. Environmental Protection Agency's (EPA's) Industrial Waste Management Guide.

1.1 Guide For Industrial Waste Management And IWEM

The EPA and representatives from 12 state environmental agencies have developed a voluntary *Guide for Industrial Waste Management* (hereafter, the *Guid*e) to recommend a baseline of protective design and operating practices to manage nonhazardous industrial waste throughout the country. The guidance was designed for facility managers, regulatory agency staff, and the public, and it reflects four underlying objectives:

- Adopt a multimedia approach to protect human health and the environment;
- Tailor management practices to risk using the innovative, user-friendly modeling tools provided in the *Guide;*
- Affirm state and tribal leadership in ensuring protective industrial waste management, and use the *Guide* to complement state and tribal programs; and
- Foster partnerships among facility managers, the public, and regulatory agencies.

The *Guide* recommends best management practices and key factors to consider to protect ground-water, surface water, and ambient air quality in siting, operating, and designing waste management units (WMUs); monitoring WMUs' impact on the environment; determining necessary corrective action; closing WMUs; and providing postclosure care. In particular, the guidance recommends risk-based approaches to design liner systems and determine waste application rates for ground-water protection, and evaluate the need for air controls. The CD-ROM version of the *Guide* includes user-friendly air and ground-water models to conduct these risk evaluations. The IWEM model described in this document, is the ground-water tool that was developed to support the *Guide*.

The IWEM software helps determine the most appropriate WMU design to minimize or avoid adverse ground-water impacts by evaluating one or more types of liners, the hydrogeologic conditions of the site, and the toxicity and expected leachate concentrations of the anticipated waste constituents. The software can help compare the ground-water protection afforded by various liner systems with the anticipated waste leachate concentrations, so that you can determine the minimum recommended liner system that will be protective of human health and ground-water resources.

The anticipated users of the IWEM software are managers of proposed or existing units, state regulators, interested private citizens, and community groups. For example:

- **Managers of a proposed unit** may use the software to determine what type of liner would be appropriate for the particular type of waste that is expected at the WMU and the particular hydrogeologic characteristics of the site.

- **Managers of an existing unit** may use the software to determine whether or not to accept a particular waste at that WMU by evaluating the performance of the existing liner design.

- **State regulators** may use the software in developing permit conditions for a WMU.

- **Interested members of the public or community groups** may use the software to evaluate a particular WMU and participate during the permitting process.

In an effort to meet the needs of the various stakeholders, the guidance for the ground-water pathway recommends a tiered approach that is based on modeling the fate and transport of waste constituents through subsurface soils to a well[2] to produce a liner recommendation. The successive tiers in the analysis incorporate more site-specific data to tailor protective management practices to the particular circumstances at the site:

- **Tier 1**: A screening analysis based upon national distributions of data;
- **Tier 2**: A location-adjusted analysis using a limited set of the most sensitive waste- and site-specific data; and
- **Tier 3**: A comprehensive and detailed site assessment

[2] In IWEM, the term "well" is used to represent an actual or hypothetical ground-water monitoring well or drinking water well, located downgradient from a WMU.

The IWEM software is designed to support the Tier 1 and Tier 2 analyses. The unique aspect of the IWEM software is that it allows the user to perform Tier 1 and Tier 2 analyses and obtain liner recommendations with minimal data requirements. Users interested in a Tier 3 analysis are directed to the *Guide* for information regarding the selection of an appropriate ground-water fate and transport model.

1.2 IWEM Design

1.2.1 What Does the Software Do?

IWEM helps you determine a recommended liner design for different types of Subtitle D WMUs that will minimize the potential for adverse ground-water impacts caused by the leaching of waste constituents. The IWEM tool compares the expected leachate concentration for each waste constituent that is entered by the user with the leachate concentration threshold value (LCTV) or exposure concentration calculated by a ground-water fate and transport model for three standard liner types. The IWEM software compiles the results for all constituents expected in the leachate and then reports the minimum liner scenario that is protective for all constituents. Table 1.1 shows the WMU types and liner types that are evaluated in IWEM.

Table 1.1 IWEM WMU and Liner Combinations

WMU Type	Liner Type		
	No Liner (in-situ soil)	**Single Clay Liner**	**Composite Liner**
Landfill	✔	✔	✔
Surface Impoundment	✔	✔	✔
Waste Pile	✔	✔	✔
Land Application Unit	✔	N/A	N/A

N/A = Not Applicable

For Land Application Units (LAUs) only the *No Liner* scenario is evaluated because liners are not typically used at this type of facility.

1.2.2 IWEM Components

The IWEM software consists of three main components (*1*) A graphical user interface (GUI) which guides you through a series of user-friendly screens to perform Tier 1 and Tier 2 evaluations; (*2*) the EPACMTP computational engine and integrated Monte Carlo processor that performs the ground-water fate and transport simulations for Tier 2 evaluations; and (*3*) a series of data bases that contain waste constituent

characteristics and WMU and ground-water modeling parameters. Each of these three components is discussed briefly below.

1. Graphical User Interface (GUI)

The IWEM GUI consists of a series of data input and display screens which allow you to define all aspects of a Tier 1 or Tier 2 evaluation. The user interface provides a tailored front-end to the EPACMTP computational engine and built-in databases for Tier 1 and Tier 2. The user interface module is described in detail in the *IWEM User's Guide* (U.S. EPA, 2002c).

2. EPACMTP Ground-Water Fate and Transport Simulation Model

EPACMTP is the computational engine of IWEM. EPACMTP simulates the migration of chemical waste constituents in leachate from land disposal units, through soil and ground water. Tier 1 leachate concentration thresholds were generated using EPACMTP. In a Tier 2 evaluation, the fate and transport simulation is performed directly inside the IWEM tool. EPACMTP is described in detail in the *EPACMTP Technical Background Document* (U.S. EPA, 2002a). This document discusses the application of EPACMTP as part of IWEM.

3. Databases

The third component of IWEM is an integrated set of databases that include Tier 1 lookup tables, as well as waste constituent properties and ground-water modeling parameters for Tier 2 evaluations. The waste constituent database includes 206 organics and 20 metals. Table 1.2 provides a list of the constituents in the database. The constituent databases includes physical and chemical data needed for ground-water transport modeling, as well as reference ground-water concentrations (RGCs), in the form of maximum constituent levels (MCLs) and cancer and non-cancer health-based numbers (HBNs) for ingestion of drinking water, and inhalation of volatiles during showering. Appendix B provides a complete list of all constituent property data.

In addition to constituent data, the IWEM tool includes a comprehensive database of ground-water modeling parameters, including infiltration rates for different WMU types and liner designs for a range of locations and climatic conditions throughout the United States, and soil and hydrogeological data for different soil types and aquifer conditions. Details of the databases are provided in this background document, and in the *EPACMTP Parameters/Data Background Document* (U.S. EPA, 2002b).

1.3 About This Document

The remainder of this document is organized as follows:

Section 2.0; *Overview of the Tier 1 and Tier 2 Approach*, presents the purpose of, and the methodology behind the Tier 1 and Tier 2 tools;

Section 3.0; *What is the EPACMTP Model*, provides an overview of the EPACMTP ground-water simulation model;

Section 4.0; *How EPA Developed the Tier 1 and Tier 2 IWEM Tools*, describes the application of EPACMTP for the development of the IWEM tools, in particular the input parameters used for Tier 1 and Tier 2;

Section 5.0; *Establishing Reference Ground-water Concentrations*, describes how we developed health-based reference concentrations (RfCs) based on ingestion and inhalation risks;

Section 6; *How Does IWEM Calculate LCTVs and Make Liner Recommendations,* describes the calculation of leachate concentration thresholds, including the development of RGCs;

Section 7.0; *References*, lists literature references;

Appendix A presents a glossary of technical terms used in this document;

Appendix B presents the list of waste constituents included in IWEM and the default values for the constituent-specific inputs (decay coefficient and organic carbon partition coefficient [K_{oc}]);

Appendix C presents tables of EPACMTP input parameters used in developing the Tier 1 LCTVs;

Appendix D presents infiltration rate data for each WMU and liner design combination;

Appendix E presents detailed information on the methodology we used to develop inhalation and ingestion HBNs; and

Appendix F presents the Tier 1 LCTV tables.

Table 1.2 IWEM Constituents

CAS Number	Constituent Name	CAS Number	Constituent Name
Organics			
83-32-9	Acenaphthene	510-15-6	Chlorobenzilate
75-07-0	Acetaldehyde [Ethanal]	124-48-1	Chlorodibromomethane
67-64-1	Acetone (2-propanone)	75-00-3	Chloroethane [Ethyl chloride]
75-05-8	Acetonitrile (methyl cyanide)	67-66-3	Chloroform
98-86-2	Acetophenone	74-87-3	Chloromethane
107-02-8	Acrolein	95-57-8	Chlorophenol 2-
79-06-1	Acrylamide	107-05-1	Chloropropene, 3- (Allyl Chloride)
79-10-7	Acrylic acid [propenoic acid]	218-01-9	Chrysene
107-13-1	Acrylonitrile	108-39-4	Cresol m-
309-00-2	Aldrin	95-48-7	Cresol o-
107-18-6	Allyl alcohol	106-44-5	Cresol p-
62-53-3	Aniline (benzeneamine)	1319-77-3	Cresols
120-12-7	Anthracene	98-82-8	Cumene
56-55-3	Benz{a}anthracene	108-93-0	Cyclohexanol
71-43-2	Benzene	108-94-1	Cyclohexanone
92-87-5	Benzidine	72-54-8	DDD
50-32-8	Benzo{a}pyrene	72-55-9	DDE
205-99-2	Benzo{b}fluoranthene	50-29-3	DDT, p,p'-
100-51-6	Benzyl alcohol	2303-16-4	Diallate
100-44-7	Benzyl chloride	53-70-3	Dibenz{a,h}anthracene
111-44-4	Bis(2-chloroethyl)ether	96-12-8	Dibromo-3-chloropropane1,2-
39638-32-9	Bis(2-chloroisopropyl)ether	95-50-1	Dichlorobenzene1,2-
117-81-7	Bis(2-ethylhexyl)phthalate	106-46-7	Dichlorobenzene1,4-
75-27-4	Bromodichloromethane	91-94-1	Dichlorobenzidine3,3'-
74-83-9	Bromomethane	75-71-8	Dichlorodifluoromethane (Freon 12)
106-99-0	Butadiene, 1, 3-	75-34-3	Dichloroethane 1,1-
71-36-3	Butanol	107-06-2	Dichloroethane1,2-
85-68-7	Butyl benzyl phthalate	156-59-2	Dichloroethylene cis-1,2-
88-85-7	Butyl-4,6-dinitrophenol,2-sec-(Dinoseb)	156-60-5	Dichloroethylene trans-1,2-
75-15-0	Carbon disulfide	75-35-4	Dichloroethylene1,1-
56-23-5	Carbon tetrachloride	120-83-2	Dichlorophenol 2,4-
57-74-9	Chlordane	94-75-7	Dichlorophenoxyacetic acid 2,4-(2,4-D)
126-99-8	Chloro-1,3-butadiene 2-(Chloroprene)	78-87-5	Dichloropropane 1,2-
106-47-8	Chloroaniline p-	542-75-6	Dichloropropene 1,3-(mixture of isomers)
108-90-7	Chlorobenzene	10061-01-5	Dichloropropene cis-1,3-
10061-02-6	Dichloropropene trans-1,3-	206-44-0	Fluoranthene
60-57-1	Dieldrin	50-00-0	Formaldehyde

Table 1.2 IWEM Constituents (continued)

CAS Number	Constituent Name	CAS Number	Constituent Name
84-66-2	Diethyl phthalate	64-18-6	Formic acid
56-53-1	Diethylstilbestrol	98-01-1	Furfural
60-51-5	Dimethoate	319-85-7	HCH beta-
119-90-4	Dimethoxybenzidine 3,3'-	58-89-9	HCH (Lindane) gamma-
68-12-2	Dimethyl formamide N,N- [DMF]	319-84-6	HCH alpha-
57-97-6	Dimethylbenz{a}anthracene 7,12-	76-44-8	Heptachlor
119-93-7	Dimethylbenzidine 3,3'-	1024-57-3	Heptachlor epoxide
105-67-9	Dimethylphenol 2,4-	87-68-3	Hexachloro-1,3-butadiene
84-74-2	Di-n-butyl phthalate	118-74-1	Hexachlorobenzene
99-65-0	Dinitrobenzene 1,3-	77-47-4	Hexachlorocyclopentadiene
51-28-5	Dinitrophenol 2,4-	55684-94-1	Hexachlorodibenzofurans [HxCDFs]
121-14-2	Dinitrotoluene 2,4-	34465-46-8	Hexachlorodibenzo-p-dioxins [HxCDDs]
606-20-2	Dinitrotoluene 2,6-	67-72-1	Hexachloroethane
117-84-0	Di-n-octyl phthalate	70-30-4	Hexachlorophene
123-91-1	Dioxane 1,4-	110-54-3	Hexane n-
122-39-4	Diphenylamine	7783-06-4	Hydrogen Sulfide
122-66-7	Diphenylhydrazine, 1, 2-	193-39-5	Indeno{1,2,3-cd}pyrene
298-04-4	Disulfoton	78-83-1	Isobutyl alcohol
115-29-7	Endosulfan (Endosulfan I and II, mixture)	78-59-1	Isophorone
72-20-8	Endrin	143-50-0	Kepone
106-89-8	Epichlorohydrin	126-98-7	Methacrylonitrile
106-88-7	Epoxybutane, 1, 2-	67-56-1	Methanol
110-80-5	Ethoxyethanol 2-	72-43-5	Methoxychlor
111-15-9	Ethoxyethanol acetate, 2-	109-86-4	Methoxyethanol 2-
141-78-6	Ethyl acetate	110-49-6	Methoxyethanol acetate 2-
60-29-7	Ethyl ether	78-93-3	Methyl ethyl ketone
97-63-2	Ethyl methacrylate	108-10-1	Methyl isobutyl ketone
62-50-0	Ethyl methanesulfonate	80-62-6	Methyl methacrylate
100-41-4	Ethylbenzene	298-00-0	Methyl parathion
106-93-4	Ethylene dibromide (1,2-Dibromoethane)	1634-04-4	Methyl tert-butyl ether [MTBE]
107-21-1	Ethylene glycol	56-49-5	Methylcholanthrene 3-
75-21-8	Ethylene oxide	74-95-3	Methylene bromide (Dibromomethane)
96-45-7	Ethylene thiourea	75-09-2	Methylene Chloride (Dichloromethane)
91-20-3	Naphthalene	1746-01-6	Tetrachlorodibenzo-p-dioxin, 2,3,7,8-
98-95-3	Nitrobenzene	630-20-6	Tetrachloroethane 1,1,1,2-
79-46-9	Nitropropane 2-	79-34-5	Tetrachloroethane 1,1,2,2-
55-18-5	Nitrosodiethylamine N-	127-18-4	Tetrachloroethylene
62-75-9	Nitrosodimethylamine N-	58-90-2	Tetrachlorophenol 2,3,4,6-

Table 1.2 IWEM Constituents (continued)

CAS Number	Constituent Name	CAS Number	Constituent Name
924-16-3	Nitroso-di-n-butylamine N-	3689-24-5	Tetraethyl dithiopyrophosphate (Sulfotep)
621-64-7	Nitroso-di-n-propylamine N-	137-26-8	Thiram [Thiuram]
86-30-6	Nitrosodiphenylamine N-	108-88-3	Toluene
10595-95-6	Nitrosomethylethylamine N-	95-80-7	Toluenediamine 2,4-
100-75-4	Nitrosopiperidine N-	95-53-4	Toluidine o-
930-55-2	Nitrosopyrrolidine N-	106-49-0	Toluidine p-
152-16-9	Octamethyl pyrophosphoramide	8001-35-2	Toxaphene (chlorinated camphenes)
56-38-2	Parathion (ethyl)	75-25-2	Tribromomethane (Bromoform)
608-93-5	Pentachlorobenzene	76-13-1	Trichloro-1,2,2-trifluoro- ethane 1,1,2-
30402-15-4	Pentachlorodibenzofurans [PeCDFs]	120-82-1	Trichlorobenzene 1,2,4-
36088-22-9	Pentachlorodibenzo-p-dioxins [PeCDDs]	71-55-6	Trichloroethane 1,1,1-
82-68-8	Pentachloronitrobenzene (PCNB)	79-00-5	Trichloroethane 1,1,2-
87-86-5	Pentachlorophenol	79-01-6	Trichloroethylene
108-95-2	Phenol	75-69-4	Trichlorofluoromethane (Freon 11)
62-38-4	Phenyl mercuric acetate	95-95-4	Trichlorophenol 2,4,5-
108-45-2	Phenylenediamine 1,3-	88-06-2	Trichlorophenol 2,4,6-
298-02-2	Phorate	93-72-1	Trichlorophenoxy)propionic acid 2-
85-44-9	Phthalic anhydride	93-76-5	Trichlorophenoxyacetic acid 2,4,5-
1336-36-3	Polychlorinated biphenyls (Aroclors)	96-18-4	Trichloropropane 1,2,3-
23950-58-5	Pronamide	121-44-8	Triethylamine
75-56-9	Propylene oxide [1,2-Epoxypropane]	99-35-4	Trinitrobenzene
129-00-0	Pyrene	126-72-7	Tris(2,3-dibromopropyl)phosphate
110-86-1	Pyridine	108-05-4	Vinyl acetate
94-59-7	Safrole	75-01-4	Vinyl chloride
57-24-9	Strychnine and salts	108-38-3	Xylene m-
100-42-5	Styrene	95-47-6	Xylene o-
95-94-3	Tetrachlorobenzene 1,2,4,5-	106-42-3	Xylene p-
51207-31-9	Tetrachlorodibenzofuran, 2,3,7,8-	1330-20-7	Xylenes (total)

Table 1.2 IWEM Constituents (continued)

CAS Number	Constituent Name	CAS Number	Constituent Name
Metals			
7440-36-0	Antimony	7439-92-1	Lead
7440-38-2	Arsenic	7439-96-5	Manganese
7440-39-3	Barium	7439-97-6	Mercury
7440-41-7	Beryllium	7439-98-7	Molybdenum
7440-43-9	Cadmium	7440-02-0	Nickel
16065-83-1	Chromium (III)	7782-49-2	Selenium
18540-29-9	Chromium (VI)	7440-22-4	Silver
7440-48-4	Cobalt	7440-28-0	Thallium
7440-50-8	Copper	7440-62-2	Vanadium
16984-48-8	Fluoride	7440-66-6	Zinc